Nitrogen flux in broad-leaved Korean pine forest land in Changbai Mountain[1]

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Abstract The flux of N in broad-leaved Korean pine forest land, Changbai Mountain, Northeast China was studied with the *in situ* sequential coring technique. The results showed that, in the growing season of 1994 (May to September), net rate of mineralization was 47.96 kg/hm^2, plant uptake 28.37 kg/hm^2 and leaching losses 20.47 kg/hm^2. Net N mineralization rate exceeded plant uptake requirements. On the basis of the N budget, this forest land could be characterized as N saturated though more detailed studies are needed.

Key words: Forest land, N flux, Growing season.

Introduction

Broad-leaved Korean pine forest is the zonal vegetation in Northeast China. The forms, transformation and transference of N in the forest land are not only important parts of material cycling in the forest ecosystem, but also concerned with important environmental questions. In order to inquire into N flux, N mineralization, plant uptake and leaching losses in the top 20 cm of the forest floor were studied with the in situ sequential coring technique from May to September of 1994.

Materials and methods

Site condition

The sample plot studied is situated in Erdaobaihe, Antu County, Jilin Province, 740 m above sea level. The mean annual temperature ranges from 0.9 to 3.9°C. The mean annual precipitation is 632.8~782.4 mm, and the total annual radiation is 509.78~515.73 kg/cm^{-2}. The soil in the area is a dark brown forest earth (alfisol), with a pH of 5.3~5.6.

The dominant tree species are *Pinus koraiensis*, *Tilia amurensis* Rupr, *Acer mono* Maxim, *Faxinus mandshurica* Rupr, *Quercus mongolica* Fisch and *Ulmus propinqua* Koidz with a mean age range of 120-245a.

Experimental method

The *in situ* sequential coring technique recommended by Raison (1987)[1] and Whynot (1991) [3] was used in this work. 8 groups of stainless steel tube with 23 cm high, 5cm in diameter and 0.1 cm in thick of tube wall were placed in the sample plot at the beginning of the experiment (May 17th). Every group of steel tube consisted of 3 tubes. After they were driven into 20 cm of soil, one of them was got back immediately with soil sample, other two were left *in situ* and cultivated. The top of the second tube was open, the third was covered with a dialyser (viscose cellulose), in order to avoid input of rainfall and other precipitate. After about 30 d of culture, 16 tubes of 8 groups left *in situ* were all collected and taken to the laboratory. In the meantime, the second experiment cultured in situ was distributed nearby.

Themical analysis

All soil samples got from the tubes were crushed and full mixed. The undecomposed litter, roots and stones were removed.

Water content of soil was measured with drying method. NO_3-N was extracted with $CaSO_4 \cdot 2H_2O$ saturated solution and analyzed with colorimetric method. NH_4-N was extracted with 2mol $\cdot$ l^{-1} KCl and determined with distilled method.[2]

Result calculation[3]

Net mineralization of N = N_e (t+1)c-Nb (t)

Plant uptake of N = N_e (t+1)c-N_b (t+1)-NI

Leaching loss of N (NI) = N_e (t+1)c-N_e (t+1) 。

Where

N_e (t+1)c = N content of soil core with cover at the end of the culture.

N_b (t) = N content of soil core at the beginning of the culture (i.e. the first tube) .

N_b(t+1) = N content of outside soil of the tubes at the end of the culture.

$N_e(t+1)_0$ = N content of soil core with open top at the end of the culture

This experiment time was divided into 4 stages (May to September) The flux of N in the growing season equals to the total of 4 stages.

The data were sorted out with Lotus-123 software, the figures were drawn with HG software.

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Results and Discussion

Change of inorganic N in growing season

Table 1 showed contents of inorganic N in 0-20 cm bulk soil collected for 5 times. NH_4-N was in the range of 10 to 26 kg/hm^2, and NO_3-N was lower than 6kg/hm^2. The total amount of inorganic N was 12-31 kg/hm^2.

Table 1. Contents of inorganic N in 0-20 cm soil layer during the growing season

Treatment	May 17th	June 21st			July 20th			Aug. 15th			Sept .13th		
	*	*	0	+	*	0	+	*	0	+	*	0	+
Water	609.8	325.2	396.4	347.3	724.9	859.3	559.6	518.0	580.2	562.7	465.5	531.9	467.2
(g * kg^{-1})	(101.0)	(62.8)	(61.5)	(31.4)	(192.5)	(207.8)	(175.9)	(109.9)	(87.6)	(92.9)	(57.6)	(101.9)	(45.9)
NH_4-N	16.48	25.55	29.09	43.45	11.27	17.31	18.77	19.88	26.83	28.66	17.98	20.14	22.81
(Kg * hm^{-2})	(4.22)	(5.57)	(6.39)	(4.61)	(3.75)	(3.75)	(3.29)	(3.77)	(5.14)	(4.10)	(1.24)	(3.76)	(4.40)
NO_3-N	2.72	5.53	11.08	10.45	1.35	2.67	2.85	1.29	2.02	1.66	0.34	2.24	3.38
(Kg * hm^{-2})	(0.33)	(1.13)	(1.71)	(1.12)	(0.17)	(0.77)	(0.52)	(0.35)	(0.28)	(0.29)	(0.21)	(0.37)	(0.78)
NH_4-N / NO_3-N	6.06	4.62	2.63	4.15	8.35	6.48	6.60	15.41	13.28	17.26	52.90	8.99	6.74
Inorganic N													
(Kg * hm^{-2})	19.20	31.08	40.17	53.90	12.62	19.98	21.62	21.17	29.03	30.32	18.32	22.38	26.19

Notes: The value was a average of 8 samples.. The value within parenthesis was the standard deviation.

* showed the bulk soil core.

o showed the soil core with open top.

\+ showed the soil core with cover.

The first stage of the culture (May to June) began at the middle ten days of May, when the 0-60 cm soil layer already melted. The content of inorganic N at the beginning of the culture was very similar to that at the end of the culture (Fig. 1). It did not almost change in winter of 6 months. It had reference to soil freeze and stop of plant growth.

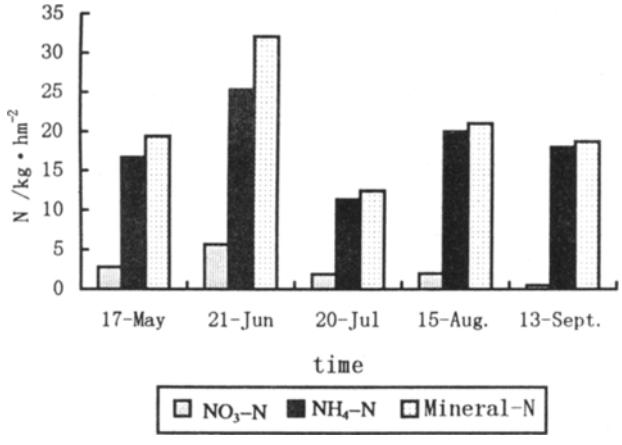

Fig. 1. Contents of mineral N in the bulk soil at different sampling time

The content of inorganic N obviously increased at the last ten days of June. It was about twice as much as that at the beginning of the culture and reached the peak in the growing season. In the meantime, its constituent also changed, NH_4-N/NO_3-N ratio reduced to 4.62 from 6.06.

This may be related to temperature increment, easy decomposition of organic N and little uptake by plants.

The value reached to minimum in the growing season at the middle ten days of July. It was relevant to unfavorable decomposition of the surplus organic N and higher plant uptake.

Along with reduction of plant growth, N uptake reduced to about half and inorganic N maintained similar level to last stage at the beginning of September.

NH_4-N was dominant in constituent of inorganic N. NH_4-N/NO_3-N ratio was in the range of 6.06 to 52.90.

N Mineralization

Table 2 showed the rates of N mineralization in every stage of the culture and the whole growing season. Net rate of mineralization in 0-20 cm soil layer was 34.70 kg/hm^2 in the first stage of the culture (May to June). Then it was -9.46 kg/hm^2 in Jun.-Jul. stage (i. e. net fixation), 17.70 kg/hm^2 in Jul.-Aug. stage and 5.02 kg/hm^2 in Aug.-Sep. Stage. The total of N mineralization was 47.96 kg/hm^2 in growing season. Its change trend was shown in Fig 2.

Table 2 The N flux in every stage of the culture and all growing season kg . hm^{-2}

Stages	May 17th-June 20th	June 21th-July 20th	July 21th-Aug.15th	Aug .16th-Sept .13th	Total(May 17th-Sept .13th)
Ammonification	26.97	-6.78	17.39	2.93	40.51
Nitrification	7.73	-2.68	0.31	2.09	7.45
Mineralization	34.70	-9.46	17.70	5.02	47.96
Plant uptake	9.09	7.36	7.86	4.06	28.37
Leaching losses	13.73	1.64	1.29	3.81	20.47

Ammonification and nitrification constitutes N mineralization. Net ammonification in every stage of the culture was shown in Table 2 and Fig. 2. Except for Jun.-Jul. stage, net ammonification of others gradually reduced along with growing period. It reached maximum (26.97 kg/hm^2) in the first stage (May-June), but negative (-6.78 kg/hm^2) in Jun.-Jul. stage. It obviously increased in Jul.-Aug. stage and again reduced in AS stage.

Change trend of net nitrification was fundamentally similar to that of ammonification. It was in the range of -2.68 to 7.73 kg/hm^2.There was a obvious nitrification in a broad-leaved Korean pine forest land.

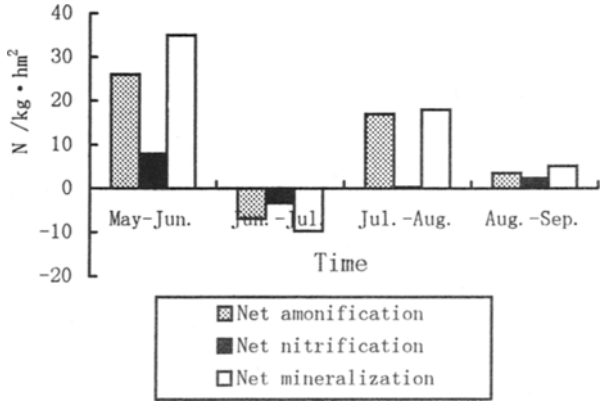

Fig. 2 Change of net amonification, nitrification and mineralization in every stage of the culture

N Balance

Change of net mineralization in every stage of the growing season was stated above.

Plant uptake mainly carries out in 0-20 cm soil layer, because the living roots there made up 88.64% of total live roots and died roots there covered 77.31% of total died roots. Plant uptake changed as follows: It was the highest (9.09 kg/hm^2) in the first stage, while the lowest (4.06 kg/hm^2) in the fourth stage. It was respectively 7.36 and 7.86 kg/hm^2 in the middle two stages. Its change fundamentally coincided with that of forest growth.

Leaching losses here meant total of inorganic N left out of 0-20cm soil layer by leaching action. Change of leaching losses in the growing season was shown in Fig. 3. It was the highest in the first stage and the lowest in the second and third stage, and slightly increased in the fourth stage. It was shown from Fig. 2 and 3 that the change trend of leaching losses was closely related with that of net nitrification. It indicated that leaching losses mainly occurred in NO_3-N.

It was shown from Table 2 that total amount of mineralization in the growing season was 47.96 kg/hm^2, plant uptake 28.37 kg/hm^2, and leaching losses 20.47 kg/hm^2. Net N mineralization exceeded the plant uptake requirements, and losses was high in the amount of inorganic N leached from 0-20 cm soil layer.

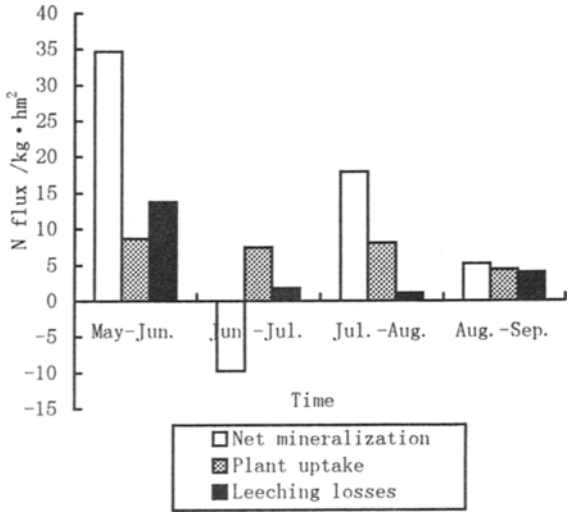

Fig. 3 N flux in every stage of the culture

Conclusions

Contents of inorganic N in 0-20 cm soil layer and rate of mineralization changed during the growing season.

Total amount of mineralization in the whole growing season was 47.96 kg/hm^2, plant uptake was 28.37 kg/hm^2 and leaching losses was 20.47 kg/hm^2. Net N mineralization rate exceeded plant uptake requirements.

Ammonification was dominant in N mineralization process, but there was a obvious net nitrification.

On the N budget, the broad-leaved Korean pine forest could be characterized as N saturated though more detailed studies are needed.

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